**CBR-045**

June 8, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| In the Matter of: | ) | |
| | ) | Docket No. 40-8943 |
| CROW BUTTE RESOURCES, INC. | ) | |
| | ) | ASLBP No. 08-867-02-OLA-BD01 |
| (License Renewal) | ) | |

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# REBUTTAL TESTIMONY OF CROW BUTTE RESOURCES WITNESSES WADE BEINS, BRYAN SOLIZ, ROBERT LEWIS, MATT SPURLIN AND LARRY TEAHON ON CONTENTIONS A, C, D, F, AND 14

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**EXPERT WITNESSES**

***A. Wade Beins***

**Q1. Please state your full name, your employer, and your position.**

A1. Wade Beins (WB). I am employed as a Senior Geologist at Crow Butte. A statement of my professional qualifications and work experience were provided previously.

**Q2. What is the purpose of your testimony?**

A2. (WB) The purpose of my testimony is to respond to the issues raised in the NRC Staff and intervenors' testimony on Contentions A, C, D, F, and 14.

**Q3. What documents have you reviewed to prepare your testimony?**

A3. (WB) I am fully familiar with the Crow Butte license renewal application ("LRA") and the NRC Staff review documents, including the Environmental Assessment ("EA") and the final Safety Evaluation Report ("SER"). I also have reviewed the testimony and exhibits submitted in this proceeding.

***B. Robert Lewis***

**Q4. Please state your full name, your employer, and your position.**

A4. Robert Lewis (RL). I am the owner and Principal Hydrogeologist of AquiferTek LLC, providing specialized hydrogeologic and environmental consulting services. A statement of my professional qualifications and work experience were provided previously.

**Q5. What is the purpose of your testimony?**

A5. (RL) The purpose of my testimony is to respond to the issues raised in the NRC Staff and intervenors' testimony on Contentions A, C, D, F, and 14.

**Q6. What documents have you reviewed to prepare your testimony?**

A6. (RL) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits submitted in this proceeding.

***C. Bryan Soliz***

**Q7. Please state your full name, employer, and position.**

A7. Bryan Soliz (BS). I am employed as a Principal Geologist for Cameco Corporation and previously worked as the Director of Exploration and Development for Cameco Resources. A statement of my professional qualifications and work experience were provided previously.

**Q8. What is the purpose of your testimony?**

A8. (BS) The purpose of my testimony is to respond to the issues raised in the NRC Staff and intervenors' testimony on Contentions A, C, D, F, and 14.

**Q9. What documents have you reviewed to prepare your testimony?**

A9. (BS) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits submitted in this proceeding.

***D.*** ***Matt Spurlin***

**Q10. Please state your full name.**

A10. Matt Spurlin (MS). I am a Senior Hydrogeologist at ARCADIS. A statement of my professional qualifications and work experience were provided previously.

**Q11. What is the purpose of your testimony?**

A11. (MS) The purpose of my testimony is to respond to the issues raised in the NRC Staff and intervenors' testimony on Contentions A, C, D, F, and 14.

**Q12. What documents have you reviewed to prepare your testimony?**

A12. (MS) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits submitted in this proceeding.

***E.*** ***Larry Teahon***

**Q13. Please state your full name, employer, and position.**

A13. Larry Teahon (LT). I am employed by Crow Butte Resources as the Safety, Health, Environment, and Quality (SHEQ) Manager at the Crow Butte facility. A statement of my professional qualifications and work experience were provided previously.

**Q14. What is the purpose of your testimony?**

A14. (LT) The purpose of my testimony is to respond to the issues raised in the NRC Staff and intervenors' testimony on Contentions A, C, D, F, and 14.

**Q15. What documents have you reviewed to prepare your testimony?**

A15. (LT) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits submitted in this proceeding.

## ASSESSMENT OF INITIAL TESTIMONY

**Q16. Can you briefly summarize your approach to responding to the issues raised in the contentions?**

A16. (All) Yes. In my direct testimony (Exh. CBR-001), I provided a brief overview of regional geology and hydrogeology before focusing on site-specific geology and hydrogeology. I then explained the various ways in which Crow Butte successfully demonstrated that the mined aquifer is confined, including borehole log data, laboratory tests of soils and rocks, water level data, water sampling data, aquifer pump tests, and operating experience. I also described Crow Butte operations, including the steps taken to control underground mining fluid and the monitoring activities associated with site operations. Finally, I addressed the specific issues raised by OST/CI.

In my rebuttal testimony, I will address the testimony of each of the intervenors' witnesses and respond to their specific points. But, at a high level, I wanted to first make an important point. While the intervenors witnesses make generalized assertions regarding geology or hydrogeology and claim that additional (or alternative) analyses should be performed, they do not identify any specific deficiency in either the NRC Staff's environmental analysis or Crow Butte's overall conclusions regarding its ability to effectively control mining fluid at the site. Crow Butte's and the NRC Staff's conclusions are based on site specific data and are supported by multiple lines of evidence, including correlated borehole logs (lithologic and geophysical), laboratory tests of confining zone cores, water quality data, water level data, aquifer pump tests, and operating experience. The data shows that low permeability layers confine the Basal

Chadron Sandstone both above and below. This isolates the Basal Chadron Sandstone from overlying and underlying aquifers. The intervenors' witnesses do not directly engage with this site-specific information.

## *A. LaGarry Testimony*

**Q17. Exhibit INT-043 is the testimony of Dr. LaGarry. Do you have any initial observations regarding his testimony?**

A17. (All) Yes, Dr. LaGarry's testimony addresses two main topics: lineaments and faults/joints. But, before addressing his specific issues, I wanted to make a general observation regarding potential faulting and jointing. Hypothetically speaking, the presence of a fault or joint does not necessarily mean there is a hydraulic connection created. Faults and joints may be barriers to groundwater flow, or neutral (*i.e.*, do not significantly affect groundwater flow), depending on the degree of offset and character of the material that fills the fault/joint. Aquifer testing (and wellfield operations) at Crow Butte would have identified the presence of significant joints or faults that affect groundwater flow given the large and overlapping radius of influence of these tests. No boundary conditions were encountered during aquifer testing that would indicate the existence of these features. So, hypothetically, even if small faults or joints do in fact exist, they are neutral and do not affect groundwater flow at the site.

**Q18. On lineaments, Dr. LaGarry states that, based on numerous small earthquakes along the Sandoz Ranch-Whiteclay Fault, the area is tectonically active to this day, though the earthquakes are relatively mild. Can you respond?**

A18. (BS, WB, MS, RL) While I acknowledge the potential for small earthquakes to occur periodically, the area is one of the most tectonically stable in the United States (Exh. CBR-001 at ¶56). Ultimately, there is no indication that the small and infrequent earthquakes that may occur would adversely impact Crow Butte's operations. I agree with the NRC Staff's testimony on seismic hazards as well. Exh. NRC-001 at A.14.2 to A.14.8.

**Q19. Dr. LaGarry also states that even small earthquakes represent shifting and flexing of the earth's crust, and are continuously creating, closing, and redistributing the secondary porosity of the region's rocks and changing the flow pathways of the region's groundwater. According to Dr. LaGarry, this means that joints incapable of transmitting water one day may be able to transmit water at a later date and that these faults connect the uranium-bearing strata to adjacent aquifers as well as modern river alluvium. Can you respond?**

A19. (BS, WB, MS, RL) As I noted in my initial testimony, there is no evidence of faulting connecting uranium-bearing strata to adjacent aquifers or alluvium. This was demonstrated through multiple lines of evidence, including aquifer pump tests and decades of mining with extensive monitoring of shallow wells. I also concur with the NRC Staff's testimony and conclusions on this issue. *See* Exh. NRC-001 (at 41-43). The NRC Staff explains that historical evidence has demonstrated that there are not continuous permeable fractures or faults at Crow Butte and that production fluids are contained within Basal Chadron Sandstone at the project site. The NRC Staff states that it is unaware of any case where

dissolution of uranium and the associated reduction of potentiometric head, such as that which exists at the CBR facility in the Basal Chadron Sandstone aquifer, would cause a fault to move. Moreover, as I explained in my initial testimony (Exh. CBR-001 at ¶48), any minor faults or fractures that did appear would close up quickly (*i.e.*, be essentially self-sealing) as a result of lithostatic pressure (*i.e.*, overburden pressure) from the weight of overlying materials.

**Q20. Dr. LaGarry also asserts, citing "Bhattacharyya & others 2012," that the absence of joints and faults in the vicinity of the proposed mine is a false perception, because joints and faults are ubiquitous in this region. Can you respond?**

A20. (MS, WB, RL) Secondary porosity is likely present in the Brule Formation throughout the region. However, primarily based on pump testing at the site and characterization of the composition of confining units above and below the production zone, there is strong evidence for hydraulic isolation and a competent upper confining unit at the site, indicating that groundwater flow pathways between the production zone and overlying aquifers are not present.

I addressed Bhattacharyya in my direct testimony (Exh. CBR-001 at ¶82). But, I add here that, while faults and joints may exist at a regional level, there is no evidence of the existence of faults or fractures at the site that affect confinement or transmit mining fluids. This is an example of the intervenors' witnesses making claims based on regional geology, but never engaging with or responding to the multiple lines of evidence demonstrating the absence of such features at the Crow Butte site.

**Q21. Dr. LaGarry states that Crow Butte Resources' assertions regarding the absence of evidence of faults is misleading, as it is possible to conduct such tests in ways that are unlikely to reveal the presence of a fault. Can you respond?**

A21. (All) There is simply no basis for implying that Crow Butte "rigged" the aquifer pump tests or otherwise questioning the professional integrity of Crow Butte and contractor employees involved in the pump tests. The pump tests complied with regulatory requirements and involved overlapping areas of influence across the length of the site. The aquifer pump testing plan was reviewed and approved by NDEQ before the testing was conducted. The plan included well locations and layouts. *See, e.g.*, Exh. CBR-012. Dr. LaGarry does not specific any specific inadequacy in the test plan.

**Q22. Can you respond to Dr. LaGarry's claim that, in order to demonstrate a lack of containment, faults must be mapped and wells installed along them?**

A22. (All) The comment is immaterial in the absence of any fault at the Crow Butte site with the potential to affect confinement. As I have discussed, there is no evidence of faulting or fracturing at the site that affects confinement or that warrants additional testing. And, Crow Butte has, in fact, conducted extensive investigation of nearby structural features, including the White River Structural Feature, which is located approximately two miles from the site. *See also* Exh. CBR-001 at ¶50 (discussing White River Structural Feature). The downhole geophysical signature for the production zone is distinct and easy to correlate between borehole locations. The 3D modeling conducted across the White River

fold structure utilized the elevations of the top and bottom contacts for the production zone based on the geophysical signatures at more than 70 borehole locations that are spatially distributed within the footprint of the fold structure. The 3D analysis permits a sophisticated evaluation of the spatial distribution and lateral correlation of marker horizons between borehole locations. Based on the 3D modeling, the very tight clustering of borehole locations across the fold structure at the North Trend Expansion Area, indicates that a linear offset feature (*i.e.*, a fault) is not present within the White River fold structure at stratigraphic horizons above the Pierre Shale. Assuming hypothetically that a fault across the Chadron Formation were present at this location, based on the distribution of marker horizons, the observed consistent northwest dip of the production zone unit within the fold structure would require that little to no fault offset be present. There is no basis (or need) for any specific assessment in the application of faults in the vicinity of Red Cloud Buttes or Smiley Canyon given their distance from the Crow Butte site.

**Q23. Can you respond to the 1989 letter referenced by the intervenors (Exh. INT-009) in which Mr. Peterson expressed concern that the uranium mined by Crow Butte occurs within the faults themselves and that mining could "uncork" the faults?**

A23. (WB, BS) The Crow Butte uranium deposit occurs within a valley fill sandstone of the Basal Chadron Formation along the trend of an early Oligocene braided stream valley that was cut into the underlying Pierre Shale. The Crow Butte ore body is interpreted to be a roll-front deposit that formed during early diagenesis of

the Whiter River Formation. According to Gjelsteen and Collings (1988) (Exh. NRC-030), ore forms at oxidation/reduction fronts in a manner similar to that of Wyoming-type deposits. These rollfront deposits are formed by the precipitation of uranium from uranium-rich, oxidized water moving through a reducing aquifer in which reducing iron rich minerals such as pyrite along with organic carbon, and bacterial byproducts cause precipitation of uranium mineralization along the oxidation/reduction boundary. The boundaries are identifiable on geophysical logs as well as visible when looking at drill cuttings collected during the drilling process.

In drill cuttings, oxidized portions of the basal sandstone of the Chadron are typically light-green to yellow in color and exhibit varying amounts of yellow-ochre staining of individual grains from the oxidation of pyrite to limonite. The reduced side of the rollfront is typically green-grey and occasionally grey-black in color depending on the amount of organic carbon present. Cuttings from the reduced side often have abundant, bright, pyrite and unaltered dark green microcline and plagioclase feldspars. The oxidized side of the fronts generally lack the presence of pyrite, or if present show heavy oxidation weathering and associated limonite pitting. Feldspars on the altered, oxidized side of the front tend to be white or pale yellow in color.

On geophysical logs, the oxidation/reduction boundaries are identifiable by the character of the gamma ray signature registered as the hole is logged. Oxidized (altered) sands typically will show a depressed or lower amount of gamma radiation through the sandy sections of an oxidized zone with a higher gamma

rate in the underlying and overlying clay zones. This altered signature often shows low grade gamma spikes of less than 2 feet in thickness at the boundary between the sand/clay interface. On the reduced side of the rollfront, the gamma measurements will be higher than the clay/shale baseline and often form a broad low grade gamma spike that typically covers the entire sand thickness.

For drill holes that intercept the oxidation/reduction boundary directly, the gamma signature is represented by a sharp, high-grade spike, usually within the heart of the sandy zone. By observing multiple drill hole lithologies and geophysical logs, Crow Butte's geologists are able to construct a map showing the location of these oxidation/reduction boundaries and use those maps for further exploration and production. *See, e.g.*, CBR-059 (roll-front cross section example). Finally, gamma readings in downhole geophysical logs from the current license area do not indicate the occurrence of uranium-bearing zones along planar surfaces that would suggest fault zones outside of the production unit. Overall, no specific evidence is referenced to support the contention that ore is present within inferred faults within the current license area.

**Q24. Do you agree with the NRC Staff testimony on the Peterson letter?**

A24. (BS, WB) Yes. As the NRC Staff explains (Exh. NRC-001 at A.D.14 and A.D.15), Crow Butte has drilled thousands of test holes and wells in the deposit that confirm the existence of roll-front deposits at Crow Butte. Roll-front origin of deposit is well documented by oxidation-reduction boundaries that have been mapped by Crow Butte. Regardless, the origin of deposit does not affect the

ability of Crow Butte to mine the deposit with ISR methods based on years of successful mining and monitoring.

**Q25. Can you address the water resources map that Dr. LaGarry obtained from Vernon Souders of the Nebraska Geological Survey?**

A25. (WB, BS) The Wyoming Fuel Company map "found" by Dr. LaGarry (Exh. CBR-043) shows a pair of faults (marked in red) intersecting Section 19, T31N R52W. This is the section where the current production plant is situated. However, this map does not provide evidence of faulting in the area. The underlying base map is a Wyoming Fuel Company map and is typical of the style of maps used early in the project for exploration and early permitting purposes. The color of the paper and blue tone ink make it easily identifiable as a "blue-line copy" of a mylar base map. That the faults are marked on the map in red marker indicates that that data was added to the map after reproduction of the base map. When the faults were drawn on the map, and by whom, is anyone's guess. But, it does not appear that the faults were drawn by the Wyoming Fuel Company (compare Exhs. INT-044 and INT-045).

Further evidence to support that the fault lines were not drawn by Wyoming Fuel Company is the title of the map. This is a Water User Map showing the location of water wells in the area surrounding the proposed permit area. Such a map would not show faults and other geologic structure except for the generalized ore trend. In fact, a photograph of Crow Butte's blue line copy of the same map does not include the red marker. Exh. CBR-058.

Finally, and most importantly, independent of unexplained markings on the map, the nearly 11,000 drill holes completed across the permit area, aquifer tests, and other evidence do not support the presence of a fault or faults in the permit area.

**Q26. Dr. LaGarry argues that depiction of the ore body shows two closely spaced variations ("kinks") in the linear trend that offset it in opposite directions as if by two closely spaced SW-NE trending faults. Can you address his claim?**

A26. (WB, BS) The generalized ore trend shown on the 1982 map does not fully define the complex nature of the roll-front systems as mapped by Crow Butte geologists. The general outline would lead one to believe that the ore trend is a solid zone of ore approximately a half mile wide. In reality, however, multiple rollfronts occur in stacked, offset groups that can be mapped to follow particular channels and are controlled in some instances as sands thin and pinch out. The "kinks" observed in the 1982 map were based on a limited amount of data, and as further development of the mining wellfield has continued, those kinks are no longer interpreted to be present. *See* Exh. CBR-055 (ore maps for main permit area).

**Q27. Dr. LaGarry claims that artesian flow occurs when there is a hydrologic connection, through faults or highly permeable strata, between groundwater sources high on the landscape and the land surface lower down and asserts that artesian flow was observed by Crow Butte Resources. Can you respond?**

A27. (MS, WB, RL) Dr. LaGarry is suggesting that faulting is serving as a conduit for vertical migration of groundwater, which he is calling it artesian flow. While the term "artesian" refers to water flowing at the surface that originates from

underground confined aquifers, Dr. LaGarry's explanation is not an entirely accurate application of the terminology to the site. Though artesian conditions have been historically present to the west (upgradient) and northwest (side gradient) of the current license area, the potentiometric surface for the confined Basal Chadron Sandstone is below ground surface within the current license area; therefore, artesian conditions do not exist. Moreover, no faults have been identified at the site, and artesian (or near artesian) flow that has been observed occurred within wells. Overall, there is no evidence of secondary porosity at the site based on multiple lines of evidence. Exh. CBR-001 at ¶58. Moreover, as I noted in my initial testimony, if faults did exist, flow in the permit area during operations would be downward and would not allow contamination of the surficial aquifer. Exh. CBR-001 at ¶44.

**Q28. Can you address LaGarry's assertions that the lineaments observed by Diffendal and others must be investigated?**

A28. (WB, BS, MS) I addressed the lineaments in my initial testimony. Nothing in the intervenors' rebuttal testimony changes my conclusions. Exh. CBR-001 at ¶55. And, I agree with the NRC Staff discussion on this topic as well. Exh. NRC-001 at 35-36. Based on the work by Diffendal (1994), lineaments were identified "throughout northwestern Nebraska." However, a specific lineament that trends through the current license area has not been identified (or ground trothed).

In addition, statistical analyses performed by Balmat (Exhibit INT-056) indicate that mapped faults and lineaments identified by remote sensing techniques are closer than random points. Statistical analyses also indicate that the observed

frequency of mapped faults with orientations within 10 degrees or less of the closest lineament is less than random. These indicate a correlation between confirmed fault and inferred lineament locations and orientations. However, field observations of 25 lineament locations failed to identify a single fault, and, as reported by Balmat and Leite (2008) (*see* abstract on page 32 of Exh. CBR-023), only one lineament in follow-up studies has been confirmed as a fault. Crow Butte does not discount the possibility that some lineaments within the Balmat study area represent faults, fractures, or joints, but the contention that all or most lineaments identified by remote sensing in the area of question represent faults identifiable on the ground simply is not supported by research. Moreover, as even Dr. LaGarry notes, lineaments identified from aerial sources cannot be confirmed as being faults or joints without field confirmation. At Crow Butte, site-specific investigations have not revealed the presence of faults or joints.

**Q29. Can you address the poster presentation by Maher and Schuster cited by Dr. LaGarry?**

A29. (WB, MS) Regional field data provided by Maher and Shuster (2012) (Exh. INT-060) support the interpretation of minor east-southeast ("ESE") trending faults and joints at the surface across the northwest portion of Nebraska. These workers also hypothesize about the source of the regional stresses. However, their work does not evaluate the depth of these features, and any conclusions regarding their hydrologic connection to the production zone is speculation. In addition, the inferred timing of the identified ESE trending features is variable and dispersed throughout the Tertiary period.

Moreover, Maher and Shuster do not specifically reference active features within or in the immediate vicinity of the current license area. The poster addresses faulting at four locations. However, all of the locations are outside the Crow Butte permit area. Crow Butte has not observed faulting or joints at the Crow Butte site. And, upward migration requires hydraulic conditions that are not present at the site. Crow Butte also has demonstrated that faulting outside the permit area does not affect Crow Butte's ability to control mining fluid at the site.

**Q30. Do you have any overall thoughts on Dr. LaGarry's testimony?**

A30. (All) Dr. LaGarry's opinions are based largely on field observations from across the region while doing research in the 1990s, culminating in the renaming of the White River Group members. Much of his opinion concerning faulting and fractures stems from observing outcrop data that is above the water table and that has been exposed to weathering. Some of the features that he claims as faults and fractures could also be explained as slump features in which a block of clay settles and slides only a few feet. These features are not likely to extend for great depth, and there has been no effort made to my knowledge to verify the depth of the features through a drilling program. In contrast, there is a vast collection of data and multiple lines of evidence specific to the Crow Butte site that demonstrates the absence of faults or fractures that affect confinement in the permit area.

Overall, Dr. LaGarry's opinions regarding conditions at Crow Butte are complete conjecture based on reconnaissance level information from the region. There is no site specific information to support his opinion. Crow Butte, in contrast, has

presented relevant site-specific data that demonstrates the absence of faulting or fracturing at the site that affects confinement or secondary porosity.

***B. <u>Kreamer Testimony</u>***

**Q31. Can you briefly describe the testimony of David K. Kreamer (Exh. INT-046)?**

A31. (All) In general, Dr. Kreamer's characterization of site geology is based on "literature" and not site-specific data. Like Dr. LaGarry, Dr. Kreamer makes broad generalizations based on regional data. In addition, a number of Dr. Kreamer's comments relate to the adequacy of established NRC requirements. The portions of Dr. Kreamer's testimony involving restoration will be addressed in the rebuttal testimony on Contentions 6 and 9.

**Q32. Do you agree with Dr. Kreamer that "there is inadequate hydrogeological site characterization" for the Crow Butte site?**

A32. (All) No. ISR facilities generally are among the most extensively studied sites in the world. An extraordinary amount of site specific hydrogeologic and geologic data has been developed and evaluated for the Crow Butte site. Currently within the permitted area, a total of 4,530 exploration and development holes have been completed, and an additional 6,330 mining and monitoring wells have been installed. Exh. CBR-056 (map of drill holes at main permit area). For nearly every hole drilled on the project, Crow Butte has completed a geophysical log and a lithology log from drill cuttings. These are reviewed by Crow Butte geologists and pertinent data is entered into the site geologic database. Monitoring well data is logged and reviewed regularly, pumping tests have been completed, and water samples have been taken regularly from surrounding wells.

**Q33. Do you agree with Dr. Kreamer (pg. 1) that secondary permeability has not been sufficiently addressed?**

A33. (MS, RL, WB) It is not clear exactly what Dr. Kreamer means by "secondary permeability." While the terms "secondary porosity" and "secondary permeability" are sometimes used somewhat synonymously, it is more common to see references to "secondary porosity." In general terms, I distinguish them as follows. *Secondary porosity* is porosity that formed due to secondary fracturing or dissolution after its deposition. It is a diagenic process subsequent to deposition or crystallization. Secondary fracturing most commonly occurs along bedding planes, faults or joints. Secondary solution porosity can result from the chemical process of dissolving rock matrix or intergranular cement, where voids are created by the mobilization of minerals (*e.g.*, dissolution of calcium carbonate in limestone). *Secondary permeability* refers to the permeability (*i.e.*, interconnectedness of pore spaces) developed in a rock after its deposition, through such processes as weathering and fracturing. Just because a rock unit possesses secondary permeability or porosity, that secondary characteristic may not always be greater than the original permeability or porosity. For example, clay is high in porosity (~40%), but has low permeability. In any event, as noted in the LRA and in my initial testimony, Crow Butte has evaluated the potential for secondary porosity at the Crow Butte site. There is no evidence of fracturing or faulting that could affect mining operations. And, there is no specific discussion of secondary permeability because there is no indication that is a potential issue of

concern. Crow Butte has not observed any containment issues that suggest secondary permeability as a mechanism that warrants detailed consideration.

**Q34. Dr. Kreamer also claims that the site hydrologic conceptual model uses simplifying assumptions and does not support claims of restricted natural vertical flow. Do you agree?**

A34. (MS, RL, WB) No, I do not agree. Crow Butte uses a calibrated site-specific groundwater model (the MBRP) that is very robust. *See* Exh. CBR-008 at ¶32. The model takes into account heterogeneity, non-uniform thickness, and other site conditions, as directly incorporated from thousands of boreholes and wells at the site. The model therefore accounts for the hydrologic limitations mentioned by Dr. Kreamer. The model does not identify any vertical hydraulic connections between the production zone and shallow aquifer. The analytical techniques described in the license application and used to assess water resource impacts are, as Dr. Kreamer notes, based on simplified models. But, that does not suggest that they are incorrect. And, in fact, they have been reaffirmed by the more than two decades of borehole and operational data, as well as the MBRP.

**Q35. Dr. Kreamer also claims (Exh. INT-046 at 2) that Crow Butte has not reported model validation, model numerical stability, uniqueness of solutions, grid intervals, or evaluation of more realistic scenarios "beyond testing a single fault."**

A35. (MS, RL, WB) Dr. Kreamer's specific concern is not clear from this statement. To the extent he is referring to the site numerical groundwater model, it is not apparent that he has even considered the publicly-available information about that

model. Dr. Kreamer also has not demonstrated that the detailed model information he claims Crow Butte must provide is necessary to demonstrate compliance with NRC requirements. And, while the current groundwater model accounts for aquifer heterogeneities, it does not include faults or joints because there is no evidence for them within the permit area. His statement ignores the fact that the "single fault" — presumably, he's referring to the White River Structural Feature — is located approximately two miles from the permit area and has been found not to affect confinement of the Basal Chadron formation. Exh. CBR-001 at ¶50. There is no basis for conducting detailed modeling of other regional faults that are located even more distant from the site. In contrast to Dr. Kreamer's speculation regarding faults (and unsupported arguments for modeling unidentified faults), Crow Butte's conclusions and those of the NRC Staff are based on detailed site specific data and operational experience that demonstrate compliance with NRC requirements.

**Q36. Can you address Dr. Kreamer's assertions that calculations of the potential for vertical flow use inappropriate and overly simplified techniques?**

A36. (MS, RL, WB) As noted previously, Crow Butte's aquifer pump tests were reviewed and approved by NDEQ and were consistent with industry standard techniques used at the time of the test. The approved analytical techniques use some simplifying assumptions, though these simplifying assumptions do not affect the conclusions. The techniques were wholly appropriate for the intended purposes.

Applying vertical anisotropy to the analytical solutions for the Basal Chadron Sandstone (the pumped aquifer) observation wells has no bearing on the estimated horizontal hydraulic conductivities. Further, horizontal anisotropy, specifically the azimuth and magnitude of the major and minor axis transmissivities of the Basal Chadron Sandstone (pumped tested formation), for each pumping test was reported in the LRA. *See, e.g.*, Exh. CBR-011 at 2-207, 2-209, and 2-210. The observed horizontal anisotropy was relatively small and the hydraulic conductivity estimates from the various pumping tests and observation wells were very similar indicating the Basal Chadron Sandstone is relatively isotropic. Regardless, the numerical model developed to support site restoration and operations accounts for any limitations or analytical models fully, and demonstrates the robust nature of those earlier evaluations.

**Q37. Did the aquifer test provide information on vertical hydraulic conductivity?**

A37. (MS, WB, RL, BS) During the test periods, observation well data indicated that leakage from the aquitards was small to negligible and secondary permeability effects were not observed. No discernable drawdown was observed in the overlying Brule Formation wells during the four pumping tests; therefore, these wells were not used in the analyses and it was concluded that these wells are hydraulically separated from the Basal Chadron Sandstone. Since a definitive vertical hydraulic conductivity could not be determined using the approved pumping test method, other lines of evidence were used to assess the vertical flow between the Brule Formation and the Basal Chadron Sandstone. The multiple lines of evidence include: (1) evaluation of geophysical data (resistivity),

geological descriptions, particle size distribution testing, soil mineralogy, and soil core permeability testing from the boreholes; and (2) evaluation of geochemical data, hydraulic gradients, and operations data from the monitoring well network. Evaluation of the geochemical groundwater data indicates that the water in the Brule Formation and the Basal Chadron Sandstone are uniquely different. The groundwater potentiometric data indicated prior to and during operation of the mine that groundwater gradients are downward; therefore, no groundwater can migrate from the Basal Chadron Formation upward into the Brule Formation. The historical operational monitoring data provides long-term evidence that mining operations are hydraulically contained. All of this data strongly indicates that the Upper Confining Units acts as an effective aquitard hydraulically separating the Brule Formation from the Basal Chadron Sandstone mining activities.

**Q38. What about Dr. Kreamer's reference to recent literature on the number and nature of the geologic faults, discontinuities, varying formation thicknesses, and the geologic history of the area?**

A38. (MS, RL, WB) Dr. Kreamer's speculation regarding site geology is based on "recent literature" and not site-specific data. Like Dr. LaGarry, Dr. Kreamer makes broad generalizations about *possible* site conditions based on regional data. While Crow Butte is aware of the recent literature on regional geology, the fact remains that information regarding regional geology or structural features located at considerable distances from the site is no substitute for the detailed, extensive site-specific information gathered by Crow Butte. Crow Butte's conclusions are supported by multiple lines of evidence and decades of operational experience.

With respect to the Brule Formation specifically, geophysical evidence indicates that: (1) there are water-bearing zones within the Brule; (2) the water-bearing zones cannot be correlated over long distances (likely due to facies changes); (3) because the water-bearing zones can't be correlated, they cannot be used to assess offsets; and (4) other marker beds (Nonpariel Ash; Upper Whitney Ash, Lower Whitney Ash) do not show offsets on a regional basis (Exh. CBR-024).

**Q39. Dr. Kreamer also claims that Crow Butte has not adequately addressed "any effects of future or past earthquakes, tectonic activity, or large pulses of infiltrating precipitation from intense storm activity." Can you respond?**

A39. (MS, RL, WB, BS) As noted above, the site is located in a seismically stable area. Regarding past seismic activity, Crow Butte has extensively studied the site geology and identified no evidence of fractures or faults that impact confinement. Regarding future earthquakes, Crow Butte provided a discussion of regional seismology in the LRA. The NRC Staff addressed the issue in the SER and the EA. In contrast to that regional and site-specific discussion, Dr. Kreamer has provided no information to suggest that additional study would lead to different conclusions or results. Finally, because Crow Butte's operational activities are limited to the Basal Chadron formation, which is hydrologically isolated from the surficial aquifer, infiltration from precipitation events would have no bearing on Crow Butte's ability to control mining fluids.

**Q40. Can you address Dr. Kramer's claim that Crow Butte does not "simulate multiple fractures beyond either a single fault, or isolated and non-interconnected faults in the system"?**

A40. (MS, RL, WB, BS) Crow Butte did not model multiple faults at the site because there is no evidence for their existence. Moreover, there is no evidence that regional faults affect confinement at the Crow Butte site.

**Q41. Please address Dr. Kreamer's complaints that information is not available on projected future groundwater use from alluvial sources.**

A41. (MS, RL, WB) There is no basis (or need) to discuss regional groundwater use from alluvial sources because alluvial groundwater is not used by Crow Butte for its operations. Moreover, the mining zone is well-confined and not connected to alluvial water sources.

**Q42. Dr. Kreamer claims that the NRC Staff (in the EA) and Crow Butte (in the LRA) describe the Brule Formation as "significantly jointed," but then complains they neither mention the number, orientation and aperture size of these "joints" in the EA. Can you address this statement.**

A42. (MS, RL, WB) First, the EA does not refer to the Brule as "significantly" jointed. Instead, the EA notes only that the Brule Formation "is unconfined and produces usable amounts of water only from areas that are sufficiently jointed to form saturated zones." Exh. NRC-010 at 47 (emphasis added). Moreover, that is a description of the Brule at a *regional* level, nor a reference to *site specific* conditions. *See* Exh. CBR-011 at 2-170 (Section 2.7.2.1, *Regional Groundwater Hydrology*). As the LRA explains (Exh. CBR-011 at 2-28), supplies of Brule Alluvium are limited, and few wells produce from this interval, none of which are located in the license area. This is confirmed by the thousands of drill holes at the site and the limited (and inconstant) water production within Brule Formation

shallow monitoring wells. Lastly, because joints, if they even exist, do not appear to extend through the Upper Confining Unit, their orientation and aperture do not affect hydraulic isolation of the Basal Chadron Sandstone from the overlying aquifer, which is separated by 200 to 500 feet of lower permeability confining materials.

**Q43. What about Dr. Kreamer's reference to the variable thickness of the Basal Chadron Sandstone?**

A43. (MS, RL, WB, BS) Thickness variations are due to the fluvial nature of the Basal Chadron Sandstone. The base of the Basal Chadron Sandstone is the eroded surface of the Pierre Shale. Variations in thickness of the unit are due to the initial infilling of low-lying areas during initial deposition of the channel-facies sandstone. Regardless, the thickness of the Basal Chadron Sandstone does not affect the hydraulic isolation of this unit from overlying and underlying aquifer units. The range in depth of the unit is due to (1) changes in ground elevation across the license area, (2) the gentle folding of the unit into a syncline within the license area, and (3) a general northwestward dip of the unit in the vicinity of the White River structure. The variability does not affect Crow Butte's ability to control mining fluids, nor does it undermine any of the five lines of evidence that support confinement. As noted above, previous modeling in the LRA is adequate for the intended purpose and is consistent with industry standard practice. Subsequent numerical modeling used to support restoration efforts accounts for aquifer heterogeneity and confirms the adequacy of prior evaluations.

**Q44. Do you agree with Dr. Kreamer that Crow Butte has performed "little" hydraulic testing of the upper confining unit?**

A44. (WB, BS, MS, RL) No. The aquifer testing involved overlapping areas of influence across the length of the site. The tests were performed in accordance with regulatory requirements (and reviewed and approved by NDEQ in advance). Because no discernable drawdown was observed in the overlying Brule Formation wells during the four pumping tests, a definitive vertical hydraulic conductivity could not be determined using the approved pumping test method. As a result, multiple lines of evidence were used to assess the vertical flow between the Brule Formation and the Basal Chadron Sandstone. These include evaluations of geophysical data (resistivity), geological descriptions, particle size distribution testing, soil mineralogy, soil core permeability testing, geochemical data, hydraulic gradients, and operational data from the monitoring well network. Testing of the age of local groundwater is not necessary, as water quality data and water level data both demonstrate that the Basal Chadron Sandstone and Brule aquifers are not connected (in addition to the pump tests and other lines of evidence).

**Q45. Is it necessary for Crow Butte to project future use and migration of deep groundwater (including the Morrison and Sundance Formations)?**

A45. (MS, RL, WB, LT, BS) No. Dr. Kreamer has not identified any impacts from Crow Butte's operations. Water in the Morrison and Sundance Formations have total dissolved solids in excess of 10,000 ppm and are at such a depth that the

formations are not considered a future source of drinking water. These issues were considered as part of the NDEQ permitting process for the Class I wells.

### *C. Wireman Testimony*

**Q46. Can you briefly describe the testimony of Michael Wireman (Exh. INT-047)?**

A46. (All) Yes. In general, Mr. Wireman's testimony ignores site-specific data. Like Dr. LaGarry and Dr. Kreamer, Mr. Wireman makes broad generalizations based on regional data. The portions of Mr. Wireman's testimony involving restoration will be addressed in the rebuttal testimony on Contentions 6 and 9.

**Q47. Can you please address Mr. Wireman's assertion that the Crow Butte has not adequately assessed secondary permeability in the upper confining unit?**

A47. (MS, RL, WB, BS) As noted above, secondary permeability has not been specifically addressed because Crow Butte has not observed any containment issues that suggest secondary permeability as a problem.

**Q48. Can you address Mr. Wireman's claim that there is a potential for unwanted fluid migration upward from the ore bearing Basal Chadron into the upper Brule aquifer?**

A48. (MS, RL, WB, BS) This issue was addressed extensively in my direct testimony. As I noted there, even if, hypothetically, there were faults or fractures connecting the Basal Chadron to the Brule at the Crow Butte site (which there are not), the vertical hydraulic gradient in the permit area during operations is strongly downward, which precludes upward migration of mining fluids into the Brule aquifer.

**Q49. Mr. Wireman references NW-SE trending faults in the region that, he claims, indicate a significant likelihood of extensive secondary porosity. Do you agree?**

A49. (MS, RL, WB, BS) No, as I explained in my initial testimony, there is no evidence of secondary porosity at the Crow Butte site. While I recognize (as referenced in the application) the existence of these regional features, their mere existence does not call into question the confinement of the Basal Chadron Sandstone at the mine site, which is supported by multiple lines of evidence.

**Q50. Do you agree with Mr. Wireman that Crow Butte (and the NRC Staff's) conclusions regarding the White River Structural Feature are insufficiently supported?**

A50. (MS, RL, WB, BS) No. More than 70 tightly-spaced borehole locations across the fold structure in the vicinity of the North Trend Expansion Area ("NTEA") were evaluated using a 3D modeling approach. Based on geophysical logging, there is adequate spatial resolution of continuous geophysical signatures across the steep fold limb for two important marker beds (Pierre Shale and Basal Chadron Sandstone) that indicate the geologic beds are not offset due to faulting. There are several other supporting lines of evidence that the deeper White River Fault does not cut upsection into the production zone and therefore does not affect the hydraulic confinement. If a permeable fault boundary did exist south of the NTEA, one would expect to have more dramatically decreased water levels near the fold structure, which has not been observed. Though the gradient direction is unaffected by the White River structure, there is a steepening of the gradient to

the south and east of COW-2 that extends through and further southeast of the fold structure. *See* Figure 22 of NTEA AEP (Exh. CBR-013). The probable causes of the steepened gradient include: (1) development of the fold structure (*i.e.*, compressional stresses) resulted in a change in pore connectivity with a localized decrease in permeability of the production zone; (2) structural thinning of the geologic units along the entire length of the fold limb resulted in reduced transmissivity (a well-documented phenomenon); (3) heterogeneity within the production zone that may reduce transmissivity; (4) spatial variation in leakage through the Upper Confining Units, which could contribute to the observed gradient change though the rate of leakage required to produce the observed change in gradient would be minimal; (5) regional influence from pumping; and (6) any combination of the above.

**Q51. Has Crow Butte confirmed the low permeability of the upper confining units?**

A51. (MS, WB, BS) Yes. As discussed in my direct testimony, site-specific testing of cores from the upper confining units have been performed and indicates very low permeability that is representative of an aquiclude. Aquifer testing data show no evidence of significant leakage that would indicate a leaky aquitard.

**Q52. Can you address Mr. Wireman's issue regarding the groundwater flow direction in the Brule?**

A52. (MS, RL, WB, BS) Mr. Wireman claims that there is uncertainty regarding flow direction in the Brule aquifer. Mr. Wireman's references to the LRA do not match those in Exh. CBR-010, which makes it difficult to understand and evaluate

his concern. Regardless, flow data for the Brule formation in Figures 2.7-3a through 2.7-3d show N-NW flow from the 1982 and the 2008-2009 time periods. This flow direction is the same as the local topography following Squaw Creek and English Creek to the White River. And, the reference to Souder (2004) is presumably a reference to page 2-170 of the CBR LRA (Exh. CBR-010) which describes *regional* flow direction and notes that groundwater flow direction depends on the location with respect to the White River.

**Q53. Mr. Wireman claims that Crow Butte should perform additional evaluations of the groundwater flow in the Brule, including aquifer tests "in areas where well yield is known to be high and in areas that have been mapped as having significant fracturing/faulting." Can you please respond?**

A53. (MS, RL, WB, BS) This supposed deficiency has no bearing on issues relevant to a review of the LRA. As noted above, Crow Butte does not use Brule aquifer water for operations. And, there is no benefit to performing aquifer tests in areas outside the permit area.[1] Further, there is already ample data and information regarding the Brule aquifer from other regional investigations. For example, there is data available from agricultural wells installed in the Brule Formation that provide abundant additional data and information from which to obtain hydraulic properties of the formation. This data can be found in publically available reports and databases.

[1] It is worth noting that characterization of the Brule Formation was not the objective of the aquifer tests. The key objectives were to understand the hydraulics of the Basal Chadron Sandstone and the overlying and underlying confining units. These objectives were met.

**Q54. Mr. Wireman asserts that the NRC Staff's explanation for the increase in the Brule hydraulic gradient is not acceptable. Can you address his assertion?**

A54. (All) The NRC Staff notes in its SER (Exh. NRC-009 at 22) a 4.5 m water rise in the Brule and an increase in the hydraulic gradient from 1983 to 2008. The NRC Staff concludes that this change is a an artifact of the number of measuring points in 2008 compared to 1983. This is a plausible explanation. Other plausible explanations include changes in precipitation patterns or fewer wells being run in the town of Crawford and surrounding area. Indeed, water levels in a phreatic/unconfined aquifer such as the Brule Formation would be expected to fluctuate naturally over a 25 year interval. Regardless, the change is largely irrelevant. Crow Butte does not mine in the Brule, nor does it consume water from the Brule. And, Mr. Wireman provides no explanation as to why the NRC Staff's conclusion is unacceptable, nor does he provide any reason to conclude that the change is the result of Crow Butte operations (or that it would impact Crow Butte's operations).

**Q55. Can you explain why only two of the four aquifer tests performed included a monitoring well in the upper confining unit?**

A55. (WB, BS) Yes. The Upper Confining Units do not contain recoverable quantities of water and therefore there is no water to monitor. If a well was installed in the upper confining layer, the only water it would likely register would be water used during installation and development. This is also the reason that Crow Butte used consolidation tests on core samples for the upper confining unit, rather than time drawdown or distance drawdown data. There simply is not a water level to

measure. And, based on data from Brule wells during aquifer testing,[2] the absence of drawdown demonstrates hydraulic isolation. Secondary permeability would be apparent in the shape of the time-drawdown curves for aquifer tests. The data clearly do not show evidence of leaky aquitards.

**Q56. Mr. Wireman claims that there is no data that indicates whether the red clay occurs over the entire extent of the mined ore body. Is that correct?**

A56. (WB, BS) No. The "red clay" marker horizon is laterally persistent across the region, and has been observed in drill cuttings as well as on geophysical logs from all across the permit area.

**Q57. Can you explain why the upper confining unit monitoring well for the 1987 aquifer test conducted in 1987 showed a response to barometric pressure during the test?**

A57. (WB) Yes. The top of the well was open to atmospheric pressure.

**Q58. Can you address Mr. Wireman's reference to "minor leakage"?**

A58. (WB, MS, RL) On page 3 of his direct testimony, Mr. Wireman characterizes the LRA as acknowledging "minor leakage" from the Upper Confining Units to the Basal Chadron Sandstone during aquifer tests, which, he claims, shows that "inter-formational flow can occur."[3] In fact, the LRA states (Exh. CBR-011 at 2-

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[2] Aquifer Test #1 utilized an upper and lower Brule observation well and drawdown was not measured in either observation well. Aquifer Test #2 included an observation well within the lower portion of the Upper Confining Unit. No measurable drawdown was observed indicating the Upper Confining Unit is a significant hydraulic barrier. The remaining two aquifer tests (#3 and #4) utilized an observation well in the Brule Formation and drawdown was not observed in the Brule Formation duration these tests.

[3] Mr. Wireman sites page 2-162 of the LRA for this statement. However, the actual reference appears to be to page 2-210 (Exh. CBR-011).

210) that the "amount of [the] recharge or leakage was extremely small, as evidenced by the piezometer responses and the drawdown analysis of the Basal Chadron Sandstone."[4] The LRA goes on to note that "[t]he overlying confining layer piezometer did not show any response attributable to the pumping." *Id.* (emphasis added). The LRA explains that the underlying confining layer piezometer showed a maximum drawdown of 0.06 foot about 4300 minutes after pumping began, but attributes this small amount of drawdown to leakage at the annulus of the packer and borehole rather than to leakage from the confining layer.

**Q59. Has Crow Butte considered the magnitude and extent of the lowered potentiometric surface that results from the production bleed?**

A59. (All) Yes, this is addressed in the LRA, SER, and EA. And, in my direct testimony on restoration, I explained that groundwater levels in the confined aquifer would quickly recover once mining is complete. Exh. CBR-001 at ¶39. I also explained that, in addition to the inward hydraulic gradient, the vertical flow direction is downward in the permit area during operations, which eliminates the potential for upward flow. Reduction of the potentiometric surface of the production zone would increase the downward hydraulic gradient between the production zone and the overlying aquifer.

**Q60. Can you address Mr. Wireman's suggestion that Crow Butte install a Basal Chadron monitoring well near Chadron to monitor the decline of the potentiometric surface and assess impacts on well yields?**

[4] An extremely small volume means less than 1 gallon per 1 foot of drawdown per acre.

A60. (All) The "area of review" for the application is 2.5 miles. Regional monitoring outside this area has not been required, nor is it necessary given the absence of significant impacts within the area of review. In any event, regional monitoring data is conducted by the Nebraska Water Resources District. Finally, the Basal Chadron Sandstone is not present for miles east of the mine site as the sandstone channel pinches out east of the deposit. It is not continuous to the City of Chadron.

**Q61. Has Crow Butte discussed the recharge or discharge areas for the Basal Chadron formation?**

A61. (All) Yes. As discussed in Exh. CBR-013 (at 40-41), the Basal Chadron Sandstone outcrops approximately 10 miles north of the North Trend Expansion Area ("NTEA"), where recharge occurs. A travel time of approximately 1,049 years was estimated between the recharge zone and the northernmost monitoring well in the NTEA (even farther/longer to current permit area). Elevations of the potentiometric surface indicate the recharge zone must be located above a minimum elevation of 3,720 feet amsl. Together, groundwater flow directions from the NTEA and current permit area suggest a discharge point at an elevation of at least approximately 3,700 feet amsl (or below) located east of Crawford, presumably at a location where the Basal Chadron Sandstone is exposed.

**Q62. Is there any need for Crow Butte to introduce a tracer to monitor flow direction?**

A62. (All) No. There is no basis (or any explanation) as to why prior and ongoing testing is inadequate. And, adding a tracer is unnecessary since excursion

parameters, which are key indicator parameters approved by the NRC and NDEQ, already provide early warning of excursions. Subsurface flow paths are modeled in the MBRP. Hydraulic testing is also performed indirectly every day as part of normal wellfield operations. Significant hydraulic boundary conditions would be apparent in operational water level and other data, as verified by frequent use of current groundwater model.

**Q63. Mr. Wireman complains that neither the LRA nor SER discuss information on the location, depth, or screened interval of the water supply wells in the groundwater monitoring program. Can you respond?**

A63. (MS, RL, WB, LT) Although data on the location, depth, and screened interval is available, it is neither necessary nor warranted to include every piece of data or information in the LRA or SER. I described the screened interval for these wells in my direct testimony, noting that the wells are screened for the most part in the Brule, though one well is screened in the Basal Chadron Sandstone. Further, the one well that is screened in the Basal Chadron Sandstone is along the hydraulic gradient between the mine site and the White River. Independent of precise location, depth, and interval, the monitoring results are documented in docketed correspondence available on ADAMS. The data does not indicate any effects from Crow Butte operations.

**Q64. Do you agree with Mr. Wireman that additional offsite sampling of the lower Brule and alluvial aquifer along the floodplains of the White River is necessary?**

A64. (All) No. While more data can always be collected, there is no need for additional monitoring in this case. As explained in my initial testimony, Crow Butte maintains a comprehensive environmental monitoring program that includes surface water and groundwater sampling, and sediment sampling, at the mine site and at background locations in the surrounding area (including the floodplains that drain into the White River). And, the majority of the shallow monitor wells are screened in the lower Brule Formation as it is the first overlying aquifer above the mining zone. There are no data to suggest a need for additional sampling beyond that already being conducted. Crow Butte also conducts its operations in a manner to minimize the potential movement of mining fluid outside the mining area and takes corrective actions as necessary.

### *D. NRC Staff Testimony*

**Q65. Have you reviewed the NRC Staff's direct testimony?**

A65. (All) Yes. I find it to be comprehensive and generally in agreement with my testimony and conclusions.

## CONCLUSIONS

**Q66. Is there anything in the intervenors' testimony or exhibits that calls in question the conclusions of your direct testimony for any of the hydrogeology contentions?**

A66. (All) No.

**Q67. What are your overall conclusions regarding the concerns by the intervenors in Contention A?**

A67. (All) All of the data and evidence available to Crow Butte indicate that both the radiological and non-radiological impacts of Crow Butte's operations are small.

Crow Butte has established through multiple lines of evidence — borehole logs, laboratory tests, water quality, water levels, aquifer pump tests, operational experience — that the Basal Chadron aquifer, where mining occurs, is isolated from overlying aquifers. In addition, Crow Butte conducts its operations to maintain hydraulic control over mining fluids and maintains an extensive environmental monitoring network to confirm control over mining fluids. For these reasons, Contention A should be resolved in Crow Butte's favor.

**Q68. What are your overall conclusions regarding the concerns by the intervenors in Contention C?**

A68. (All) Crow Butte has taken active steps to minimize the potential for either surface or subsurface leaks or spills to cause environmental harm to the White River, including use of berms or dikes to protect these waterbodies. Regular monitoring of Squaw and English Creeks shows that Crow Butte's operations are not adversely impacting surface waters in the mine area. If leaks and spills were to occur, Crow Butte is required to take immediate corrective actions, including restoration of the environment. Moreover, Crow Butte maintains an extensive environmental monitoring network that would detect any migration of mining fluids beyond the license area, including testing of water quality in private wells outside the mining area. At bottom, there are no data to indicate impacts to the White River from Crow Butte's operations. For these reasons, Contention C should be resolved in Crow Butte's favor.

**Q69. What are your overall conclusions regarding the concerns by the intervenors in Contention D?**

A69. (All) Crow Butte has established through multiple lines of evidence — borehole logs, laboratory tests of cores, water quality data, water level data, aquifer pump test results, and operational experience — that the Basal Chadron aquifer, where mining occurs, is hydraulically isolated from overlying aquifers. In addition, Crow Butte conducts its operations to maintain hydraulic control over mining fluids and maintains an extensive environmental monitoring network to confirm control over mining fluids. All of the testing and operational experience to date confirms the absence of faults or fractures that could transmit mining fluid into aquifers that provide drinking water to the Pine Ridge Reservation. For these reasons, Contention D should be resolved in Crow Butte's favor.

**Q70. What are your overall conclusions regarding the concerns by the intervenors in Contention F?**

A70. (All) While there have been recent studies of the regional geology that have resulted in the proposal of a new nomenclature for some of the geologic units within the license area, including proposals by Dr. LaGarry, these studies do not indicate that any portion of the LRA was inadequate. In discussing regional geology, Crow Butte, the NRC Staff, and NDEQ continue to use the nomenclature found in the prior license applications for consistency and to facilitate public review and comparison. Most importantly, stratigraphic nomenclature aside, nothing in the naming conventions for the geologic units in Nebraska or at the Crow Butte facility changes the interpretation of the physical or hydraulic features of the geologic units presented by Crow Butte. For these reasons, Contention F should be resolved in Crow Butte's favor.

**Q71. What are your overall conclusions regarding the concerns by the intervenors in Contention 14?**

A71. (All) Crow Butte considered the potential impacts of earthquakes at the site prior to beginning operations. Crow Butte also recognizes the potential for small faults and fractures to occur in the sediments overlying the mined aquifer. Additionally, there may be limited areas of secondary permeability within isolated areas of the Brule Formation. However, aquifer pump tests have confirmed adequate upper confinement due to the thick sequence of overlying low permeability silt and clay and the absence of any faults or fractures that would permit a preferential permeability pathway for impacted groundwater to migrate into overlying aquifers. All of the testing and operational experience to date confirms the absence of faults or fractures that could transmit mining fluid into aquifers outside the mined area. Based on the available data, including thousands of boreholes, any fractures or faults that did occur would be of very limited extent. This has been confirmed by the four pump tests, which as noted above demonstrate confinement. For these reasons, Contention 14 should be resolved in Crow Butte's favor.